

Role of Vortex Rossby Waves on Tropical Cyclone Intensity

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LONG-TERM GOALS

The long-term goal of this project is to improve the prediction of tropical cyclone (TC) genesis and intensity changes through improved understanding of the fundamental mechanisms involved. Accurate prediction of TC intensity changes is critical to Navy mission and civilian activities. Significant gains have been made in the TC track prediction over the past three decades. The intensity forecast, however, has shown very little improvement during the same period. A main factor contributing to the lack of skill in the prediction of TC intensity is the inadequate understanding of complicated mechanisms involved. These mechanisms include internal dynamic and thermodynamic processes, external forcing, and scale interactions. Only after we understand these processes, are we then able to tackle the weaknesses in the model simulations and forecasts.

OBJECTIVES

The objective of this project is to understand how asymmetric disturbances, often generated by local convection, affect TC intensity and structure change. Two focus areas of the study include: 1) the effect of different characteristics of externally exposed asymmetries on the axisymmetrization of TCs, and 2) the evolution of stable and unstable waves and their impacts on the basic vortex.

APPROACH

For the first part of the study listed under the objectives, our approach is to use an idealized TC model to investigate vortex axisymmetrization for different basic vortex profiles and different asymmetries. The model developed will be used as a barotropic or a baroclinic model. Idealized vortices resembling realistic TC radial profile, and asymmetries representing disturbances from convection will be prescribed. Diagnostic tools will be developed to analyze results from model integrations. For the second part of the study, wind profiles with radial shear instability in the inner or the outer part, or both, will be investigated to understand the growth and decay of vortex Rossby modes with different wave numbers. To investigate the instability characteristics of TC wind profiles, Eigen system for barotropic vorticity equation will be built and stable and unstable Eigen values and Eigen modes will be investigated.

WORK COMPLETED

This is a new project started in FY07. So far, we have investigated the effect of different initial positions of the asymmetry on the axisymmetrization process in a linear and a nonlinear barotropic

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model. The results are discussed in the following section. In addition, we have completed construction of the Eigen system for the barotropic vorticity equation.

RESULTS

Previous studies on vortex axisymmetrization indicate that asymmetries imposed near the radius of maximum wind can lose their energy quickly while propagating outward due to differential rotation of the basic vortex. In our study, we find that when asymmetries are placed at outer radii, a newly induced inner asymmetry can obtain energy from the basic state due to an upshear tilt, and this weakens the basic state for a substantial period of time. Later on, when the asymmetries are sheared by the differential rotation of the basic state wind, the asymmetries become tilted downshear and give energy back to the basic state. The tilt of the asymmetry in the early stage depends on the position of the initial asymmetry. The closer the asymmetry is, the larger the phase tilts. However, closer asymmetry also experiences greater differential rotational effects and the phase tilt reverts to downshear faster. These two factors act in opposition to each other on the effectiveness of energy transfer between the asymmetry and the symmetry. Therefore, a critical radius can be obtained such that when an asymmetry is placed initially, the energy transfer between the asymmetry and the basic state will be largest. This represents a completely new understanding on vortex axisymmetrization.

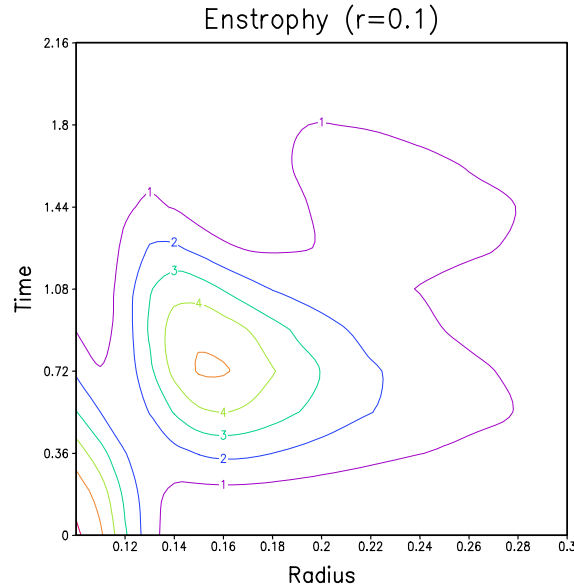


Figure 1. Energy exchange represented by the asymmetric enstrophy at the radius of the maximum wind as a function of different positions of the initial asymmetry. In the figure, the maximum occurs when the initial asymmetry is placed about 1.5 the radius of the maximum wind.

IMPACT/APPLICATIONS

The understanding of how asymmetries gain or lose energy to and from the basic state of a hurricane-like vortex is critical to improve our prediction of the TC genesis and intensity change.

RELATED PROJECTS

This project is closely related to the NRL 6.2 funded project “Predicting tropical cyclone genesis using NOGAPS”. Knowledge gained from this project will help to improve the prediction of tropical cyclone genesis.

PUBLICATIONS

Peng, J.-Y., M. S. Peng, T. Li, 2006: Some aspects of vortex axisymmetrization: Part I: Effects of initial asymmetric structure and nonlinearity. *J. Atmos. Sci.*, (Submitted).

PRESENTATIONS

Jiayi Peng, M. S. Peng, and T. Li, 2006: Effects of baroclinicity and different initial asymmetries on vortex axisymmetrization. 27th Conference on Hurricane and Tropical Meteorology, 24-28 April 2006, Monterey, CA.